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- **Patent Application No. 2002-164336 (P2002-164336A)**

is a true and complete translation of the same document from the **Japanese** language. The document was translated by an accredited translator.

Michelle Arrué

(signature)

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(54) Title of Invention: Gas Injector and Film Formation Apparatus

(57) Summary: To provide a gas injector and film formation apparatus that is able to form a film at a uniform film thickness across the entire surface of one wafer or a plurality of wafers.
Solution Means: The spray nozzles 80, 81, 105, 107 for the same kind of reaction gas are plurally divided in the lengthwise direction, and the reaction gases introduced into the interior of the gas injector 51 by the respective spray nozzles are respectively

independently caused to flow through the interior of the gas injector 51 toward the respective corresponding spray nozzles. Then, by respectively controlling the amounts of gas introduced into the reaction gas introduction holes 58, 59, 60, 61 formed according to the number of spray nozzles, the gas spray amounts from the respective spray nozzles are individually controlled.

58 1st reaction gas introduction hole
62 Inert gas introduction hole
61 2nd reaction gas introduction hole

Claims

Claim 1: A gas injector characterized by the fact that, in a gas injector which is constituted by combining
a top plate on which is formed
a 1st reaction gas introduction hole connected with a 1st reaction gas supply source via a 1st reaction gas introduction tube,
a 1st gas conduit for the 1st reaction gas which communicates with said 1st reaction gas introduction hole,
a 2nd reaction gas introduction hole connected with a 2nd reaction gas supply source via a 2nd reaction gas introduction tube,
a 2nd reaction gas conduit for the 2nd reaction gas which communicates with said 2nd reaction gas introduction hole,
a 2nd reaction gas plenum chamber which communicates with said 2nd reaction gas conduit and extends in the lengthwise direction,
an inert gas introduction hole connected with an inert gas supply source via an inert gas introduction tube,
and a 1st gas conduit for the inert gas which communicates with said inert gas introduction hole;
a center plate which is stacked and aligned with said top plate and on which is formed
a 2nd gas conduit for the 1st reaction gas which communicates with said 1st gas conduit for the 1st reaction gas,
a 2nd gas conduit for the inert gas which communicates with said 1st gas conduit for the inert gas,
an inert gas plenum chamber which communicates with said 2nd gas conduit for the inert gas and extends in the lengthwise direction,
and a 2nd reaction gas spray nozzle which communicates with said 2nd reaction gas plenum chamber and extends in the lengthwise direction;
a bottom plate which is stacked and aligned with said center plate and on which is formed
a 3rd gas conduit for the 1st reaction gas which communicates with said 2nd gas conduit for the 1st reaction gas,
a 1st reaction gas plenum chamber which communicates with said 3rd gas conduit for the 1st reaction gas and extends in the lengthwise direction,
and an inert gas spray nozzle which communicates with said inert gas plenum chamber and extends in the lengthwise direction outside said 2nd reaction gas spray nozzle;

and a base plate which is stacked and aligned with said bottom plate and on which is formed

a 1st reaction gas spray nozzle which communicates with said 1st reaction gas plenum chamber and extends in the lengthwise direction outside said inert gas spray nozzle;

said 1st reaction gas plenum chamber is plurally divided in the lengthwise direction, and, corresponding to this divided 1st reaction gas plenum chamber, said 1st reaction gas introduction tube, said 1st reaction gas introduction hole, said 1st gas conduit for the 1st reaction gas, said 2nd gas conduit for the 1st reaction gas, said 3rd gas conduit for the 1st reaction gas, and said 1st reaction gas spray nozzle are provided;

said 2nd reaction gas plenum chamber is plurally divided in the lengthwise direction, and, corresponding to this divided 2nd reaction gas plenum chamber, said 2nd reaction gas introduction tube, said 2nd reaction gas introduction hole, said 2nd reaction gas conduit, and said 2nd reaction gas spray nozzle are provided;

gas flow volume control means are respectively provided in said plurality of 1st and 2nd reaction gas introduction tubes; and

the gas flow volumes which are introduced to said plurality of 1st and 2nd reaction gas introduction holes are respectively controlled through said respective gas flow volume control means.

<u>Claim 2:</u> A gas injector described in Claim 1, characterized in that said gas flow volume control means are manual control valves which manually regulate the distribution ratio of the gas flow volumes to said plurality of 1st and 2nd reaction gas introduction holes.

<u>Claim 3:</u> A film formation apparatus, characterized in that, in a film formation apparatus which is equipped with

a support means which supports a wafer;

a heating means which heats said wafer;

a top plate on which is formed

a 1st reaction gas introduction hole connected with a 1st reaction gas supply source via a 1st reaction gas introduction tube,

a 1st gas conduit for the 1st reaction gas which communicates with said 1st reaction gas introduction hole,

a 2nd reaction gas introduction hole connected with a 2nd reaction gas supply source via a 2nd reaction gas introduction tube,

a 2nd reaction gas conduit which communicates with said 2nd reaction gas introduction hole,

a 2nd reaction gas plenum chamber which communicates with said 2nd reaction gas conduit and extends in the lengthwise direction,

an inert gas introduction hole connected with an inert gas supply source via an inert gas introduction tube, and

a 1st gas conduit for the inert gas which communicates with said inert gas introduction hole;

a center plate which is stacked and aligned with said top plate and on which is formed

a 2nd gas conduit for the 1st reaction gas which communicates with said 1st gas conduit for the 1st reaction gas,

a 2nd gas conduit for the inert gas which communicates with said 1st gas conduit for the inert gas,

an inert gas plenum chamber which communicates with said 2nd gas conduit for the inert gas and extends in the lengthwise direction, and

a 2nd reaction gas spray nozzle which communicates with said 2nd reaction gas plenum chamber, extends in the lengthwise direction and opposes said wafer;

a bottom plate which is stacked and aligned with said center plate and on which is formed

a 3rd gas conduit for the 1st reaction gas which communicates with said 2nd gas conduit for the 1st reaction gas,

a 1st reaction gas plenum chamber which communicates with said 3rd gas conduit for the 1st reaction gas and extends in the lengthwise direction, and

an inert gas spray nozzle which communicates with said inert gas plenum chamber, extends in the lengthwise direction outside said 2nd reaction gas spray nozzle, and opposes said wafer;

and a base plate which is stacked and aligned with said bottom plate and on which is formed

a 1st reaction gas spray nozzle which communicates with said 1st reaction gas plenum chamber, extends in the lengthwise direction outside said inert gas spray nozzle, and opposes said wafer;

said 1st reaction gas plenum chamber is plurally divided in the lengthwise direction, and, corresponding to this divided 1st reaction gas plenum chamber, said 1st reaction gas introduction tube, said 1st reaction gas introduction hole, said 1st gas conduit for the 1st reaction gas, said 2nd gas conduit for the 1st reaction gas, said 3rd gas conduit for the 1st reaction gas, and said 1st reaction gas spray nozzle are provided;

said 2nd reaction gas plenum chamber is plurally divided in the lengthwise direction, and, corresponding to this divided 2nd reaction gas plenum chamber, said 2nd reaction gas introduction tube, said 2nd reaction gas introduction hole, said 2nd reaction gas conduit, and said 2nd reaction gas spray nozzle are provided; and

gas flow volume control means are respectively provided in said plurality of 1st and 2nd reaction gas introduction tubes; and

the gas flow volumes which are introduced to said plurality of 1st and 2nd reaction gas introduction holes are respectively controlled through said gas flow volume control means.

Claim 4: A film formation apparatus described in Claim 3, characterized in that said gas flow volume control means are manual control valves which manually regulate the gas flow volume distribution ratio to said plurality of 1st and 2nd reaction gas introduction holes.

Claim 5: A film formation apparatus described in Claim 3, characterized in that an exhaust tube which exhausts the gases blown onto said wafer by said 1st reaction gas spray nozzle, said 2nd reaction gas spray nozzle, and said inert gas spray nozzle is provided in the vicinity of said gas injector.

Detailed Explanation of the Invention

[0001]

Technical Field of the Invention This invention concerns a gas injector that blows a gas which is a material for forming a film on a wafer, in the CVD method, in which a thin

film is grown on a wafer by means of a chemical vapor; it also concerns a film formation apparatus that is equipped with this gas injector.

[0002]

Prior Art CVD methods include the atmospheric pressure CVD method, the reduced pressure CVD method, the plasma CVD method, and the optical CVD method. These methods are used in fields of application appropriate to their respective characteristics. Among these, the atmospheric pressure CVD method does not require a vacuum apparatus, etc., so the structure of this apparatus is relatively simple.

[0003] Fig. 16 shows an example of an atmospheric pressure CVD apparatus. For example, wafers 1a, 1b with a diameter of six inches are loaded onto a belt conveyor 2, so that they are aligned in two rows along the transport direction A. The wafers 1a, 1b are heated from below to approximately 400°C by a heater 3. Three gas injectors 4 are provided in such a way that they are aligned along the transport direction A above the center of the belt conveyor 2. The lower surfaces of these gas injectors are placed facing the belt conveyor 2 with a gap between them and the belt conveyor, so that they do not interfere with the passing of the wafers 1a, 1b.

[0004] A hydride reaction gas, such as SiH_4 or PH_3, as the 1st reaction gas, O_2 gas as the 2nd reaction gas, and an inert gas (N_2 gas), which separates the 1st reaction gas and the 2nd reaction gas and adjusts the reaction positions of these reaction gases, are blown from the lower surfaces of the gas injectors 4. Decomposition and chemical reactions are caused on the heated wafers 1a, 1b, and an SiO_2 film is accumulated and formed on the wafers 1a, 1b. The respective gases are fed into the gas injectors 4 from the gas input tubes 5, 6, 7 connected to the upper surfaces of the gas injectors 4, and they are blown out from gas spray nozzles formed on the lower surfaces corresponding with the respective gases.

[0005] Gas flow volume control means (MFC: mass flow controller) 8 for adjusting the gas flow volume are respectively provided on the 1st reaction gas input tube 5, the 2nd reaction gas input tube 7 and the N_2 gas input tube 6.

[0006] The gas injectors 4 have, for example, the configuration shown in Unexamined Patent Application Publication No. HEI10[1998]-312997, and this gas injector 4 configuration will be explained next, referring to Figs. 13 through 15.

[0007] Fig. 13 is a top view of the gas injector 4, Fig 14 is a cross sectional drawing along line [14]-[14] of Fig. 13, and Fig. 15 is a cross sectional drawing along line [15]-[15] of Fig. 14.

[0008] The gas injector 4 is configured by combining a base plate 9, a bottom plate 10, a center plate 11 and a top plate 12 stacked in sequence from the bottom. The respective plates are fastened together with bolts.

[0009] First, the top plate 12 will be explained.

[0010] As shown in Fig. 13, three gas introduction holes, a 1st reaction gas introduction hole 13, a 2nd reaction gas introduction hole 14, and an N_2 gas introduction hole 15, are formed in the vicinity of the center portion of the upper surface of the top plate 12

[0011] As shown in Fig. 14, the 1st reaction gas introduction hole 13 connects with the 1st reaction gas introduction tube 5 that is connected with the 1st reaction gas supply source, the 2nd reaction gas introduction hole 14 connects with the 2nd reaction gas introduction tube 7 that connects with the 2nd reaction gas supply source, and the N_2 gas introduction hole 15 connects with the N_2 gas introduction tube 6, which connects with the N_2 gas supply source.

[0012] The 1st reaction gas introduction hole 13 communicates with the 1st gas conduit 16 for the 1st reaction gas, which is formed in the top plate 12. The 1st gas conduit 16 for the 1st reaction gas consists of an L-shaped gas conduit 16a which communicates with the 1st reaction gas introduction hole 13, a gas conduit 16b which communicates with this gas conduit 16a and extends along the lengthwise direction, two gas conduits 16c which respectively communicate with both ends of this gas conduit 16b and extend along the short direction, and four gas conduits 16d which respectively communicate with both ends of these gas conduits 16c, extend in the downward direction, and go through the lower surface of the top plate 12.
[0013] The 2nd reaction gas introduction hole 14 communicates with the 2nd reaction gas conduit 17 formed in the top plate 12. This 2nd reaction gas conduit 17 consists of an L-shaped gas conduit 17a that communicates with the 2nd reaction gas introduction hole 14, a gas conduit 17b which communicates with this gas conduit 17a and extends along the lengthwise direction, two gas conduits 17c which respectively communicate with both ends of this gas conduit 17b and extend in the short direction, and four gas conduits 17d which respectively communicate with both ends of these gas conduits 17c, and extend in the downward direction.
[0014] As shown in Fig. 14, the gas conduits 17d are respectively provided in a depressed manner along the lengthwise direction from the bottom surface of the top plate, and they communicate with two 2nd reaction gas plenum chambers 18 which form a space with the upper surface of the center plate 11 which extends in the lengthwise direction via a gas conduit 19 formed between the upper surface of the center plate 11 and the lower end of the top plate 12.
[0015] As shown in Fig. 15, the 2nd reaction gas plenum chamber 18 is formed as a continuous space along the lengthwise direction.
[0016] The N_2 gas introduction hole 15 communicates with the 1st gas conduit 20 for the N_2 gas formed in the top plate 12. The 1st gas conduit 20 for the N_2 gas consists of a gas conduit 20a that communicates with the N_2 gas introduction hole 15, a gas conduit 20b that communicates with this gas conduit 20a and extends along the lengthwise direction, two gas conduits 20c that respectively communicate with both ends of this gas conduit 20b and extend along the short direction, and four gas conduits 20d that respectively communicate with both ends of these two gas conduits 20c, extend in the downward direction, and go through the lower surface of the top plate.
[0017] Next, the center plate 11 will be explained.
[0018] As shown in Fig. 14, a 2nd gas conduit 21 for the 1st reaction gas is formed on the center plate 11 in such a way that it penetrates through the center plate in the vertical direction.
[0019] In addition, the 2nd reaction gas spray nozzle 23 is formed at the center portion of the center plate 11 by means of mutually opposing vertical wall portions 22 that extend along the lengthwise direction. The 2nd reaction gas spray nozzle 23 opens along a direction that is perpendicular to the wafer transport direction A, extends to the lower end of the base plate 9, and opposes the wafers 1a, 1b of both the front side row and the back side row.
[0020] In addition, the 2nd gas conduit 24 for N_2 gas is formed on the center plate 11 in such a way that it penetrates through the center plate in the vertical direction. Then, the 2nd gas conduit 24 for the N_2 gas is provided in a depressed manner along the lengthwise direction from the lower surface side of the center plate 11, and it communicates via a gas

conduit 26 with two N_2 gas plenum chambers 25 which form a space with the upper surface of the bottom plate 10 that extends in the lengthwise direction. As shown in Fig. 15, the N_2 gas plenum chamber 25 is formed as a continuous space in the lengthwise direction.

[0021] Also, the top plate 12 and the center plate 11 are stacked and aligned so that the four gas conduits 16d are caused to communicate with the four gas conduits 21 that correspond to them the four gas conduits 20d are caused to communicate with the four gas conduits 24d that correspond to them and the 2nd reaction gas plenum chamber 18 is caused to communicate with the 2nd reaction gas spray nozzle 23. The 2nd reaction gas plenum chamber 18 and the 2nd reaction gas spray nozzle 23 communicate via a gas conduit 27 that is formed between the lower surface of the top plate 12 and the upper surface of the center plate 11 and extends in the lengthwise direction.

[0022] Next, the bottom plate 10 will be explained.

[0023] As shown in Fig. 14, a 3rd gas conduit 28 for the 1st reaction gas is formed on the bottom plate 10 in such a way that it penetrates through the bottom plate in the vertical direction. Four 3rd gas conduits 28 for the 1st reaction gas are formed to correspond to the four 2nd gas conduits 21 for the reaction gas formed in the center plate 11.

[0024] The 3rd gas conduits 28 for the 1st reaction gas are respectively provided in a depressed manner in the lengthwise direction from the lower surface side of the bottom plate 10, and they communicate via gas conduits 30 with two 1st reaction gas plenum chambers 29 which form a space with the upper surface of the base plate 9 which extends in the lengthwise direction.

[0025] As shown in Fig. 15, a 1st reaction gas plenum chamber 29 forms a continuous space in the lengthwise direction.

[0026] In addition, mutually opposing vertical wall portions 31 which extend in the lengthwise direction in such a way as to flank the 2nd reaction gas spray nozzle 23 are formed on the center portion of the bottom plate 10, and an N_2 gas spray nozzle 32 is formed between the vertical wall portions 22 formed in the center plate 11. This N_2 gas spray nozzle 32 is formed in a rectangular ring shape in such a way that it surrounds the 2nd reaction gas spray nozzle, it opens in a direction perpendicular to the wafer transport direction A, it extends to the lower end of the base plate 9, it opposes the wafers 1a, 1b of both the front side row and the back side row.

[0027] The center plate 11 and the bottom plate 10 are stacked and aligned so that the 2nd gas conduit 21 for the 1st reaction gas is caused to communicate with the 3rd gas conduit 28 for the 1st reaction gas, and the N_2 gas plenum chamber 25 is caused to communicate with the N_2 gas spray nozzle 33. The N_2 gas plenum chamber 25 and the N_2 gas spray nozzle 32 communicate via a gas conduit 33 which is formed between the bottom surface of the center plate 11 and the upper surface of the bottom plate 10 and extends in the lengthwise direction.

[0028] Next, the base plate 9 will be explained.

[0029] As shown in Fig. 14, mutually opposing vertical wall portions 34 which extend in the lengthwise direction so as to flank the N_2 gas spray nozzle 32 are formed in the center portion of the base plate 9, and a 1st reaction gas spray nozzle 35 is formed between the vertical wall portions 31 formed in the bottom plate 10. This 1st reaction gas spray nozzle 35 is formed in a rectangular ring shape in such a way that it surrounds the N_2 gas spray nozzle 32, it opens along a direction perpendicular to the wafer transport direction A, it causes the 2nd reaction gas spray nozzle 23 and the N_2 gas spray nozzle 32 to match up at

the lower ends, and it opposes the wafers 1a, 1b of both the front side row and the back side row.

[0030] In addition, a cooling water conduit 36 is formed on the base plate 9; this conduit 36 is connected with cooling water piping which is not shown in the diagram.

[0031] The bottom plate 10 and the base plate 9 are stacked and aligned so that the 1st reaction gas plenum chamber 29 is caused to communicate with the 1st reaction gas spray nozzle 35. The 1st reaction gas plenum chamber 29 and the 1st reaction gas spray nozzle 35 communicate via a gas conduit 37 which is formed between the lower surface of the bottom plate 10 and the upper surface of the base plate 9 and extends in the lengthwise direction.

[0032] Conventional gas injectors 4 and film formation apparatuses are configured in the above way, and their operation will be explained next.

[0033] First, the flow of the 1st reaction gas (hydride gas) will be explained.

[0034] From the 1st reaction gas input tube 5, the 1st reaction gas input to the 1st reaction gas input hole 13 formed in the upper surface of the top plate 12 flows through the gas conduits 16a-16d formed in the top plate 12, gas conduit 21 formed in the center plate 11, and gas conduits 28, 30 formed in the bottom plate 10, and reaches the 1st reaction gas plenum chamber 29.

[0035] Then, it is divided in the lengthwise direction in the 1st reaction gas plenum chamber 29, passes through gas conduit 37, and is sprayed from the 1st reaction gas spray nozzle 35 onto the wafers 16a, 16b of both the front side row and the back side row in Fig. 16.

[0036] Next, the flow of the 2nd reaction gas (O_2 gas) will be explained.

[0037] From the 2nd reaction gas input tube 7, the 2nd reaction gas, which is introduced to the 2nd reaction gas input hole 14 formed in the upper surface of the top plate 12, flows through the gas conduits 17a-17d, 19 formed in the top plate 12, and reaches the 2nd reaction gas plenum chamber 18.

[0038] Then, it is divided in the lengthwise direction in the 2nd reaction gas plenum chamber 18, passes through gas conduit 27, and is sprayed from the 2nd reaction gas spray nozzle 23 onto the wafers 1a, 1b of both the front side row and the back side row.

[0039] Next, the flow of the N_2 gas will be explained.

[0040] From the N_2 gas introduction tube 6, the N_2 gas introduction to the N_2 gas introduction hole 15 formed in the upper surface of the top plate 12 flows through the gas conduits 20a-20d formed in the top plate 12 and through the gas conduits 24, 26 formed in the center plate 11, and reaches the N_2 gas plenum chamber 25.

[0041] Then it is divided in the lengthwise direction in the N_2 gas plenum chamber 25, passes through gas conduit 33, and is sprayed from the N_2 gas spray nozzle 32 onto the wafers 1a, 1b of both the front side row and the back side row.

[0042]

Problems To Be Solved by the Invention In this type of gas injector 4, a gas which is introduced via piping with a relatively small diameter is ultimately dispersed and blown out in the lengthwise direction, so the gas forms a complex flow within the gas injector 4. Furthermore, due to such factors as the way the four plates are combined and the accuracy of assembly, the gas flow in the gas injector 4 becomes intermittent and spatially non-uniform, and the respective reaction gases are not sprayed evenly in the lengthwise direction of the respective spray nozzles. Therefore, in the wafers 1a of the front side row and the wafers 1b of the back side row, the reaction volume of the 1st

reaction gas and the 2nd reaction gas becomes non-uniform, and variations are produced in the accumulated film thickness. In a conventional gas injector 4, since there is only one gas conduit for the respective reaction gases inside the gas injector, it was not possible to individually adjust the gas flows of the front side and the back side of the respective gas spray nozzles. Therefore, for example, even if the difference in film thickness was several nm, it was not considered to be a problem up to now. In recent years, however, the miniaturization of semiconductors has advanced, and this slight disparity of several nm of film thickness has come to have an effect on the pattern width formed by the lithography process, which is performed after the film formation process.

[0043] The present invention takes the aforementioned problems into account and has as its purpose the provision of a gas injector and a film formation apparatus that are capable of film formation at a uniform film thickness across the entire surface of a single wafer or of a plurality of wafers.

[0044]

Means of Solving the Problems To solve these problems, the gas injector of the present invention is such that a 1st reaction gas plenum chamber is plurally divided - in the lengthwise direction, and, corresponding to this divided 1st reaction gas plenum chamber, a 1st reaction gas introduction tube which connects with a 1st reaction gas supply source, a 1st reaction gas introduction hole which connects with this 1st reaction gas introduction tube, a 1st gas conduit for the 1st reaction gas which communicates with this 1st reaction gas introduction hole, a 2nd gas conduit for the 1st reaction gas which communicates with this 1st gas conduit for the 1st reaction gas, a 3rd gas conduit for the 1st reaction gas which communicates with this 2nd gas conduit for the 1st reaction gas and the 1st reaction gas plenum chamber, and a 1st reaction gas spray nozzle which communicates with the 1st reaction gas plenum chamber are provided. The 2nd reaction gas plenum chamber is plurally divided in the lengthwise direction, and, corresponding to this divided 2nd reaction gas plenum chamber, a 2nd reaction gas input tube which connects with the 2nd reaction gas supply source, a 2nd reaction gas input hole which connects with the 2nd reaction gas input tube, a 2nd reaction gas conduit which communicates with this 2nd reaction gas introduction hole and the 2nd reaction gas plenum chamber, and a 2nd reaction gas spray nozzle which communicates with the 2nd reaction gas plenum chamber are provided. Gas flow volume control means are respectively provided in the plurality of 1st and 2nd reaction gas introduction tubes, and the gas flow volumes which are introduced into the plurality of 1st and 2nd reaction gas introduction holes are respectively controlled through these respective gas flow volume control means.

[0045] Also, the film formation apparatus of the present invention is such that it is equipped with a support means, which supports a wafer, a heating means which heats the wafer, and a gas injector, which blows gas onto the wafer. This gas injector is such that a 1st reaction gas plenum chamber is plurally divided in the lengthwise direction, and, corresponding to this divided 1st reaction gas plenum chamber, a 1st reaction gas introduction tube which connects with a 1st reaction gas supply source, a 1st reaction gas introduction hole which connects with a 1st reaction gas supply source, a 1st reaction gas introduction hole - which connects with this 1st reaction gas introduction tube, a 1st gas conduit for the 1st reaction gas which communicates with this 1st reaction gas introduction hole, a 2nd gas conduit for the 1st reaction gas which communicates with this 1st gas conduit for the 1st reaction gas, a 3rd gas conduit for the 1st reaction gas which communicates with this 2nd gas conduit for the 1st reaction gas and the 1st reaction gas

plenum chamber, and a 1st reaction gas spray nozzle that communicates with the 1st reaction gas plenum chamber and opposes the wafer are provided. The 2nd reaction gas plenum chamber is plurally divided in the lengthwise direction, and, corresponding to this divided 2nd reaction gas plenum chamber, a 2nd reaction gas introduction tube which connects with the 2nd reaction gas supply source, a 2nd reaction gas introduction hole which connects with this 2nd reaction gas introduction tube, a 2nd reaction gas conduit which communicates with this 2nd reaction gas introduction hole and the 2nd reaction gas plenum chamber, and a 2nd reaction gas spray nozzle which communicates with the 2nd reaction gas plenum chamber and opposes the wafer are provided. Gas flow volume control means are respectively provided in the plurality of 1st and 2nd reaction gas introduction tubes. The gas flow volumes that are introducted to the plurality of 1st and 2nd reaction gas introduction holes are respectively controlled through these respective gas flow volume control means.

[0046] That is, in the present invention, spray nozzles for the same kind of reaction gas are plurally divided in the lengthwise direction, and the reaction gases introduced into the interior of the gas injector to correspond to the respective spray nozzles respectively independently flow through the interior of the gas injector toward the respective corresponding spray nozzles. Therefore, the gas spray volumes from the respective spray nozzles are individually controlled by respectively controlling the gas input volumes going to the reaction gas input holes formed according to the number of spray nozzles. Therefore, the gas spray volumes from the respective spray nozzles are individually controlled by respectively controlling the gas input volumes going to the reaction gas input holes formed according to the number of spray nozzles.

[0047]

<u>Embodiments of the Invention</u> Embodiments of the present invention will be explained below, referring to the drawings.

[0048] Fig. 1 is a perspective view that gives a partial cross section of the gas injector 51 resulting from the present invention, Fig. 2 is a top view, Fig. 3 is a bottom view, Fig. 4 is a cross sectional drawing along line [4]-[4]. of Fig. 2, Fig. 5 is a cross section drawing along line [5]-[5] in Fig. 4, Fig. 6 is a cross sectional drawing along line [6]-[6] of Fig. 4, Fig. 7 is a cross sectional drawing along line [7]-[7] of Fig. 4, and Fig. 8 is a cross sectional drawing along line [8]-[8]of Fig. 5.

[0049] The gas injector 51 of this embodiment is constituted by assembling a base plate 52, a bottom plate 53, a center plate 54, and a top plate 55 stacked in order from the bottom. The respective plates are tightly secured to each other by threading nuts 57 on bolts 56 that have been inserted through from the base plate 52 side at the upper surface of the top plate 55.

[0050] First, the top plate 55 will be explained.

[0051] As shown in Fig. 2, two 1st reaction gas introduction holes 58, 59, two 2nd reaction gas introduction holes 60, 61 and one inert gas introduction hole 62 are formed in the vicinity of the center portion of the upper surface of the top plate 55.

[0052] As shown in Fig. 1, the 1st reaction gas introduction hole 59 communicates with the 1st gas conduit for the 1st reaction gas formed in the top plate 55. The 1st gas conduit 63 for the 1st reaction gas consists of an L-shaped gas conduit 63a, which communicates with the 1st gas introduction hole 59, a gas conduit 63b which communicates with this gas conduit 63a and extends along the lengthwise direction toward the back side, a gas conduit 63c - which communicates with this gas conduit 63b and extends in the short

direction, and two gas conduits 63d which respectively communicate with both ends of this gas conduit 63c, extend downward, and go through the bottom surface of the top plate 55.
[0053] Another 1st reaction gas introduction hole 58 communicates with the 1st gas conduit 64 for the 1st reaction gas formed in the top plate 55 independently of the aforementioned 1st gas conduit 63 for the 1st reaction gas. The 1st gas conduit 64 for the 1st reaction gas consists of an L-shaped gas conduit 64a, which communicates with the 1st gas introduction hole 58, a gas conduit 64b which communicates with this gas conduit 64a and extends in the lengthwise direction toward the front side, a gas conduit 64c which communicates with this gas conduit 64b and extends in the short direction, and two gas conduits 64d which respectively communicate with both ends of this gas conduit 64c, extend downward, and go through the bottom surface of the top plate 55.
[0054] The 1st reaction gas introduction hole 58 connects to the 1st reaction gas introduction tube 65 (shown in Fig. 4), which connects to the 1st reaction gas (a - hydride gas such as SiH_4 or PH_3) supply source. In the same way, another 1st reaction gas introduction hole 59 also connects to the 1st reaction gas supply source via a 1st reaction gas supply tube which is separate from the above 1st reaction gas supply tube 65.
[0055] As shown in Fig. 1, the 2nd reaction gas introduction hole 61 communicates with the 2nd reaction gas conduit 66 formed in the top plate 55. The 2nd reaction gas conduit 66 consists of an L-shaped gas conduit 66a which communicates with a 2nd reaction gas introduction hole 61, a gas conduit 66b which communicates with this gas conduit 66a and extends in the lengthwise direction toward the back side, a gas conduit 66c which communicates with this gas conduit 66b and extends in the short direction, and two gas conduits 66d that respectively communicate with both ends of this gas conduit 66c and extend downward.
[0056] Another 2nd reaction gas introduction hole 60 communicates with the 2nd reaction gas conduit 67 formed in the top plate 55 independently of the aforementioned 2nd reaction gas conduit 66. As is also explained with reference to Fig. 4, the 2nd reaction gas conduit 67 consists of an L-shaped gas conduit 67a, which communicates with the 2nd reaction gas introduction hole 60, a gas conduit 67b which communicates with this gas conduit 67a and extends in the lengthwise direction toward the front side, a gas conduit 67c which communicates with this gas conduit 67b and extends in the short direction, and two gas conduits 67d which respectively communicate with both ends of this gas conduit 67c and extend downward.
[0057] As shown in Fig. 4, two gas conduits 67d are respectively provided in a depressed manner in the lengthwise direction from the lower surface side of the top plate 55; they communicate with two 2nd reaction gas plenum chambers 68 which form a space with the upper surface of the center plate 54 which extends in the lengthwise direction via a gas conduit 69 formed between the upper surface of the center plate 54 and the lower end of the top plate 55.
[0058] With respect to gas conduit 66d as well, as shown in Fig. 1, these are respectively provided in a depressed manner in the lengthwise direction from the lower surface side of the top plate 55, and they communicate with two 2nd reaction gas plenum chambers 70 (in Fig. 1, only one of the 2nd reaction gas plenum chambers is shown) which form a space with the upper surface of the center plate 54 which extends in the lengthwise direction via a gas conduit 71 formed between the upper surface of the center plate 54 and the lower end of the top plate 55.

[0059] As shown in Fig. 5, which is a cross sectional diagram in the direction of the [5]-[5] line in Fig. 4, 2nd reaction gas plenum chamber 68 and 2nd reaction gas plenum chamber 70 are separated by a partition 72 that extends downward from the top plate 55 and that comes into contact with the upper surface of the center plate 54.
[0060] As shown in Fig. 5, the 2nd reaction gas introduction hole 60 comes into contact with a 2nd reaction gas introduction tube 73 which connects with the supply source of the 2nd reaction gas (for example, O_2 gas). In the same way, another 2nd reaction gas introduction hole 61 is also connected to the supply source of the 2nd reaction gas via a 2nd reaction gas introduction tube 74 which is separate from the above 2nd reaction gas introduction tube 73.
[0061] As shown in Fig. 1, an inert gas which hole 62 communicates with a 1st gas conduit 75 for the inert gas formed in the top plate 55. The 1st gas conduit 75 for the inert gas consists of a gas conduit 75a, which communicates with the inert gas introduction hole 62, a gas conduit 75b which communicates with this gas conduit 75a and extends - in the lengthwise direction, two gas conduits 75c which respectively communicate with both ends of this gas conduit 75b and extend in the short direction, and four gas conduits 75d which respectively communicate with both ends of these two gas conduits 75c, extend downward, and go through the lower surface of the top plate 55.
[0062] The inert gas introduction hole 62 connects with the inert gas introduction tube 76 (shown in Fig. 4), which connects with an inert gas (for example, N_2 gas) supply source.
[0063] Next the center plate 54 will be explained.
[0064] As shown in Figs. 1 and 4, 2nd gas conduits 77, 78 for the 1st reaction gas are formed in the center plate 54 in such a way as to go through it in the vertical direction. Two 2nd gas conduits 77 for the 1st reaction gas are formed to correspond to the two gas conduits 63d formed in the top plate 55, and two 2nd gas conduits 78 for the 1st reaction gas are formed to correspond to the two gas conduits 64d formed in the top plate 55.
[0065] In addition, as shown in Fig. 4, a 2nd reaction gas spray nozzle 80 is formed in the center portion of the center plate 54 by means of mutually opposing vertical wall portions 79 which extend in the lengthwise direction. As shown in Figs. 1, 3 and 7, this 2nd reaction gas spray nozzle 80 is separated from another 2nd reaction gas spray nozzle 81 formed in the same way by means of a partition 83 that extends from the top plate 55 to the lower end of the base plate 52.
[0066] In addition, a 2nd gas conduit 84 for N_2 gas is formed in the center plate 54 in such a way as to go through it in the vertical direction. Four 2nd gas conduits 84 for N_2 gas are formed to correspond to the four gas conduits 75d formed in the top plate 55.
[0067] In addition, as shown in Figs. 1 and 4, the 2nd gas conduit 84 for N_2 gas is provided in a depressed manner in the lengthwise direction from the lower surface side of the center plate 54, and it communicates with two N_2 gas plenum chambers 85 which form a space with the upper surface of the bottom plate 53 which extends in the lengthwise direction via a gas conduit 86.
[0068] As shown in Fig. 5, the N_2 gas plenum chamber 85 is formed as a continuous space in the lengthwise direction.
[0069] In addition, the top plate 55 and the center plate 54 are stacked and aligned in such a way that the 1st gas conduit 63d for the 1st reaction gas is caused to communicate with the 2nd gas conduit 77 for the 1st reaction gas, the 1st reaction gas conduit 64d for the 1st reaction gas is caused to communicate with the 2nd gas conduit 78 for the 1st reaction gas, the 1st gas conduit 75d for N_2 gas is caused to communicate with the 2nd gas conduit 84

for N_2 gas, the 2nd reaction gas plenum chamber 68 is caused to communicate with 2nd reaction gas spray nozzle 80, and the 2nd reaction gas plenum chamber 70 is caused to communicate with 2nd reaction gas spray nozzle 81. The 2nd reaction gas plenum chamber 68 and the 2nd reaction gas spray nozzle 80 communicate via a gas conduit 87 which is formed between the lower surface of the top plate 55 and the upper surface of the center plate 54 and extends in the lengthwise direction. In the same way, the 2nd reaction gas plenum chamber 70 and the 2nd reaction gas spray nozzle 81 communicate via a gas conduit 88.

[0070] As shown in Fig. 6, which is a cross sectional drawing along line [6]-[6] in Fig.4, four 1st reaction gas seal rings 89, four N_2 gas seal rings 90 and two 2nd reaction gas seal rings 91 are interposed between the top plate 55 and the center plate 54 for the purpose of preventing gas leakage.

[0071] Next, the bottom plate 53 will be explained.

[0072] As shown in Figs. 1 and 4, third gas conduits 92, 93 for the 1st reaction gas are formed in the bottom plate 53; they penetrate through it in the vertical direction. Two 3rd gas conduits 92 for the 1st reaction gas are formed corresponding to the two gas conduits 78 formed in the center plate 54, and two 3rd gas conduits 93 for the 1st reaction gas are formed corresponding to the two gas conduits 77 formed in the center plate 54.

[0073] Of these, as shown in Fig. 4, the respective 3rd gas conduits 92 for the 1st reaction gas are provided in a depressed manner in the lengthwise direction from the lower surface side of the bottom plate 53, and communicate via a gas conduit 95 with two 1st reaction gas plenum chambers 94 which form a space with the upper surface of the base plate 52 that extends in the lengthwise direction.

[0074] As shown in Fig. 1, the other respective 3rd gas conduits 93 for the 1st reaction gas are provided in a depressed manner along the lengthwise direction from the lower surface side of the bottom plate 53; they communicate via a gas conduit 97 with two 1st reaction gas plenum chambers 96 (only one of the 1st reaction gas plenum chambers is shown in Fig. 1) which form a space with the upper surface of the base plate 52 which extends in the lengthwise direction.

[0075] As shown in Fig. 5, the 1st reaction gas plenum chamber 94 and the 1st reaction gas plenum chamber 96 are separated by means of a partition 98 which extends downward from the bottom plate 53 and comes into contact with the upper surface of the base plate 52.

[0076] In addition, as shown in Fig. 4, mutually opposing vertical wall portions 99 which extend along the lengthwise direction in such a way as to flank the 2nd reaction gas spray nozzles 80, 81 are formed in the center portion of the bottom plate 53, and an N_2 gas spray nozzle 100 is formed between the vertical wall portions 79 formed in the center plate 54. As shown in Fig. 3, this N_2 gas spray nozzle 100 is formed in a rectangular ring shape in such a way that it surrounds the 2nd reaction gas spray nozzles 80, 81.

[0077] Also, the center plate 54 and the bottom plate 53 are stacked and aligned in such a way that the 2nd gas conduit 78 for the 1st reaction gas is caused to communicate with the 3rd gas conduit 92 for the 1st reaction gas, the 2nd gas conduit 77 for the 1st reaction gas is caused to communicate with the 3rd gas conduit 93 for the 1st reaction gas, and the N_2 gas plenum chamber 85 is caused to communicate with the N_2 gas spray nozzle 100. The N_2 gas plenum chamber 85 and the N_2 gas spray nozzle 100 communicate via a gas conduit 101 which is formed between the lower surface of the center plate 54 and the upper surface of the bottom plate 53 and extends in the lengthwise direction.

[0078] As shown in Fig. 7, which is a cross sectional drawing along line [7]-[7] in Fig. 4, four 1st reaction gas seal rings 102 and one N_2 gas seal ring 103 are interposed between the center plate 54 and the bottom plate 53 for the purpose of preventing gas leakage.
[0079] Next, the base plate 52 will be explained.
[0080] As shown in Fig. 4, mutually opposing vertical wall portions 104 which extend in the lengthwise direction in such a way as to flank the N_2 gas spray nozzles 100 are formed in the center portion of the base plate 52, and a 1st reaction gas spray nozzle 105 is formed between the vertical wall portions 99 formed in the bottom plate 53. As shown in Fig. 3, this 1st reaction gas spray nozzle 105 is separated from the 1st reaction gas spray nozzle 107 formed in the same way by means of a partition 106 that extends downward from the bottom plate 53. Therefore, two 1st reaction gas spray nozzles 105, 107 are respectively formed in a reversed "C" shape.
[0081] The 1st reaction gas spray nozzles 105, 107 match up with the 2nd reaction gas spray nozzles 80, 81 and N_2 gas spray nozzle 100 at their respective lower ends.
[0082] In addition, the cooling water conduit 36 is formed on the base plate 52; this conduit 36 is connected with cooling water piping which is not shown in the diagram.
[0083] Also, the base plate 52 and the bottom plate 53 are stacked and aligned in such a way that the 1st reaction gas plenum chamber 94 is caused to communicate with 1st reaction gas spray nozzle 105, and the 1st reaction gas plenum chamber 96 is caused to communicate with the 1st reaction gas spray nozzle 107. The 1st reaction gas plenum chamber 94 and the 1st reaction gas spray nozzle 105 communicate via a gas conduit 108 which is formed between the lower surface of the bottom plate 53 and the upper surface of the base plate 52 that extends in the lengthwise direction. In the same way, the 1st reaction gas plenum chamber 96 and the 1st reaction gas spray nozzle 107 communicate via a gas conduit 109.
[0084] In addition, two 1st reaction gas seal rings 110 (shown by the broken lines in Fig. 3) are interposed between the base plate 52 and the bottom plate 53 for the purpose of preventing gas leaks.
[0085] Fig. 9 shows a schematic drawing of a gas injector 51 configured in the following way. Gas flow volume control means (electromagnetic valves) 8 are respectively provided to the 1st reaction gas introduction tubes 65, 111, 2nd reaction gas input tubes 73, 74 and N_2 gas input tube 76, and the gas flow volumes which respectively flow through these five input tubes can be individually controlled.
[0086] In addition, as shown in Fig. 17, an exhaust tube 112 is provided in the vicinity of the gas injector 51, and an exhaust fan is connected to this exhaust tube 112. The part of the gas that was blown onto the wafers 1a, 1b but has not formed the film is exhausted via this exhaust tube 112.
[0087] The film formation apparatus (atmospheric pressure CVD apparatus) resulting from this embodiment is equipped with the gas injector 51 discussed above. That is, instead of the gas injector 4 shown in Fig. 16, a gas injector 51 with the aforementioned configuration is installed.
[0088] The gas injector 51 and the film formation apparatus resulting from this embodiment are configured in the above way, and the operation thereof will be explained next.
[0089] First, the flow of the 1st reaction gas (hydride group gas) will be explained.
[0090] From the 1st reaction gas input tube 65, the 1st reaction gas, which has been introduced to the 1st reaction gas input hole 58 formed in the upper surface of the top

plate 55, flows through the gas conduits 64a-64d formed in the top plate 55, the gas conduit 78 formed in the center plate 54, and the gas conduits 92, 95 formed in the bottom plate 53 and reaches the 1st reaction gas plenum chamber 94.

[0091] Then, it is dispersed in the lengthwise direction in the 1st reaction gas plenum chamber 94, passes through the gas conduit 108, and is sprayed from the 1st reaction gas spray nozzle 105 onto the wafers 1a in the front side row which opposes this 1st reaction gas spray nozzle 105.

[0092] In the same way, from the other 1st reaction gas introduction tube, the 1st reaction gas, which has been introduced to the 1st reaction gas introduction hole 59 formed in the upper surface of the top plate 55, flows through the gas conduits 63a-63d formed in the top plate 55, the gas conduit 77 formed in the center plate 54, and the gas conduits 93, 97 formed in the bottom plate 53 and reaches the 1st reaction gas plenum chamber 96.

[0093] Then, it is dispersed in the lengthwise direction in the 1st reaction gas plenum chamber 96, passes through the gas conduit 109, and is sprayed from the 1st reaction gas spray nozzle 107 onto the wafers 1b in the back side row that opposes this 1st reaction gas spray nozzle 107.

[0094] Next, the flow of the 2nd reaction gas (O_2 gas) will be explained.

[0095] From the 2nd reaction gas input tube 73, the 2nd reaction gas, which has been input to the 2nd reaction gas input hole 60 formed in the upper surface of the top plate 55, flows through the gas conduits 67a-67d, 69 formed in the top plate 55, and reaches the 2nd reaction gas plenum chamber 68.

[0096] Then, it is dispersed in the lengthwise direction in 2nd reaction gas plenum chamber 68, passes through the gas conduit 87, and is sprayed from the 2nd reaction gas spray nozzle 80 onto the wafers 1a in the front side row that opposes this 2nd reaction gas spray nozzle 80.

[0097] In the same way, from the 2nd reaction gas introduction tube 74, the 2nd reaction gas, which has been introduced to the 2nd reaction gas introduction hole 61 formed in the upper surface of the top plate 55, flows through gas conduits 66a-66d, 71 formed in the top plate 55 and reaches the 2nd reaction gas plenum chamber 70.

[0098] Then, it is dispersed in the lengthwise direction in the 2nd reaction gas plenum chamber 70, passes through the gas conduit 88, and is sprayed from the 2nd reaction gas spray nozzle 81 onto the wafers 1b in the back side row that opposes this 2nd reaction gas spray nozzle 81.

[0099] Next, the flow of the N_2 gas will be explained.

[0100] From the N_2 gas introduction tube 76, the N_2 gas, which has been introduced to the N_2 gas introduction hole 62 formed in the upper surface of the top plate 55, flows through the gas conduits 75a-75d formed in the top plate 55 and the gas conduits 84, 86 formed in the center plate 54 and reaches the N_2 gas plenum chamber 85.

[0101] Then, it is dispersed in the lengthwise direction in the N_2 gas plenum chamber 85, passes through the gas conduit 101, and is sprayed from the N_2 gas spray nozzle 100 onto the wafers 1a, 1b in the front side row and the back side row that oppose this N_2 gas spray nozzle 100.

[0102] In the above manner, the respective gases are blown onto the wafers 1a, 1b from the respective spray nozzles, they disperse and react on the heated wafers 1a, 1b, and an SiO_2 film is formed. Then, the respective gas spray nozzles of the 1st and 2nd reaction gases are divided in two for the front side wafers 1a and the back side wafers 1b, and then the 1st and 2nd reaction gases independently flow through the interior of the gas injector

51 to the respective gas spray nozzles. Therefore, by adjusting each of the four independent flows of the 1st and 2nd reaction gases, that is, the gas input volumes going to the four gas input holes 58, 59, 60, 61 respectively, using a gas flow volume control means 8, the spray volumes from the respective gas spray nozzles can be made such that they do not become non-uniform on the front side and the back side and so that variations are not produced in the thickness of the film formed on the front side wafers 1a and the back side wafers 1b.

[0103] Next, a second embodiment of the present invention will be explained. Note that the same codes will be assigned to the same structural portions as in the first embodiment, and the details thereof will be omitted.

[0104] The gas injector 120 resulting from this embodiment is shown in Fig. 10. This gas injector 120 differs from the gas injector 51 of the above first embodiment only in the configuration of the 1st and 2nd reaction gas introduction tubes and the gas flow volume control means provided thereon.

[0105] The 1st reaction gas introduction tube 121 consists of a common tube 121a which connects with the 1st reaction gas supply source and two branching tubes 121b, 121c connected to this common tube 121a via the gas flow volume control means 123. The two branching tubes 121b, 121c respectively connect to the 1st reaction gas introduction holes 58, 59 formed in the upper surface of the top plate 55.

[0106] In the same way, the 2nd reaction gas introduction tube 122 consists of a common tube 122a which connects with the 2nd reaction gas supply source and the two branching tubes 122b, 122c connected to this common tube 122a via gas flow volume control means 123. The two branching tubes 122b, 122c respectively connect to the 2nd reaction gas introduction holes 60, 61 formed in the upper surface of the top plate 55.

[0107] The gas flow control means 123 are manual control valves and both have the same configuration, so only one of the manual control valves 123 will be explained, with reference to Figs. 11 and 12. Fig. 11 shows a horizontal cross sectional drawing of the manual control valve 123, and Fig. 12 shows a cross sectional drawing along line [12-[12] of Fig. 11.

[0108] The shaft portion 126 of the adjustment knob 125 goes through the interior of the casing 124 which communicates with the common tube 121a and the two branching tubes 121b, 121c with two O-rings 127a, 127b between them. The knob portion 128 is attached to the upper end of the shaft portion 126 to form a single unit, and a disc spring 129 which has an elastic force pressing upward is interposed between this knob portion 128 and the upper surface of the casing 124. The nut 130 is threaded on the male screw portion 126a of the front end of the shaft portion 126, and a disc spring 131, which has an elastic force pressing downward is interposed between this nut 130 and the lower surface of the casing 124. Therefore, the adjustment knob 125 is such that its position is held with respect to the casing 124 by means of the elastic forces of the two upper and lower disc springs 129, 131.

[0109] A partition plate 132 that protrudes toward the external diameter is attached to the shaft portion 126 in such a way that they form a single unit. The two branching tubes 121b, 121c are separated by the partition plate 132 and a partition portion 133 that extends from the inner wall of the casing 124 toward the shaft portion 126. Also, when the knob portion 128 is rotated in opposition to the position holding force resulting from the elastic forces of the two upper and lower disc springs 129, 131, the shaft portion 126 and the partition portion 132 are rotated in the direction of arrow B shown in Fig. 11, and

the flow volume distribution of the 1st reaction gas which flows to the branching tubes 121b, 121c from the common tube 121a is controlled.

[0110] In the present invention, there is an increase in the amount of gas introduction tubes compared to the prior art, and therefore the flow volume control means that are positioned in the respective introduction tubes also increase by that amount. Therefore, by using this type of manual control valve, it is possible to obtain a less expensive configuration than is the case when an expensive automatic control valve 8, such as that of the first embodiment, is used.

[0111] The respective embodiments of the present invention were explained above, but the present invention is, of course, not limited to these, and various alterations are possible based on the technical concepts of the present invention.

[0112] In the above embodiment, the wafers are in two rows in the transport direction, but they may also be in three rows or more. In addition, the number of independent flows of the reaction gases may also be formed according to the number of rows. However, when too many independent flows are formed, the number of introduction tubes and the flow volume control means increase by that amount, so the piping space becomes large, and costs increase. Or, the wafers may be such that there is a large aperture and there is one row, and in such a case as well, a film can be uniformly formed across the entire surface of the wafer by means of the present invention.

[0113] In addition, in the manual control valve 123 of the second embodiment, which is shown in Fig. 12, one may secure the adjustment knob 125 to the casing 124 in the specified position by merely tightening the nut 130 without using upper and lower disc springs 129, 131, and when the adjustment knob 125 is rotated, the nut 130 may be loosened and rotated.

[0114]

Effects of the Invention Through Claim 1 of the present invention, it is possible to uniformly form a film without producing variations in the film thickness on the wafer with respect to the lengthwise direction of the gas injector, and an improvement of the yield can be obtained.

[0115] Through Claim 2 of the present invention, it is possible to restrict the cost increases of the gas flow volume control valve which accompany an increase in the amount of piping of the gas introduction tubes.

[0116] Through Claim 3 of the present invention, it is possible to uniformly form a film without generating differences in film thickness on the wafer with respect to the lengthwise direction of the gas injector, and an improvement of the yield can be obtained.

[0117] Through Claim 4 of the present invention, it is possible to restrict the cost increases of the gas flow volume control valve which accompany an increase in the amount of piping of the gas input tubes.

[0118] Through Claim 5 of the present invention, by adjusting the reaction gas exhaust speed after it has been blown onto the wafer, it is possible to more accurately control the film thickness.

Brief Explanation of the Drawings

Fig. 1 Fig. 1 is a perspective view, which gives a partial cross section of the gas injector resulting from an embodiment of the present invention.

Fig. 2 Fig. 2 is a top view of the same gas injector.

Fig. 3 Fig. 3 is a bottom view of the same gas injector.

Fig. 4 Fig. 4 is a cross sectional drawing along line [4]-[4] of Fig. 2.

Fig. 5 Fig. 5 is a cross sectional drawing along line [5]-[5] in Fig. 4.

Fig. 6 Fig. 6 is a cross sectional drawing along line [6]-[6] of Fig. 4.

Fig. 7 Fig. 7 is a cross sectional drawing along line [7]-[7] of Fig. 4.

Fig. 8 Fig. 8 is a cross sectional drawing along line [8]-[8] of Fig. 5.

Fig. 9 Fig. 9 is a schematic drawing, which shows the connection relationship between the gas injector and the gas input tube which connects to it.

Fig. 10 Fig. 10 is an external perspective view of the gas flow volume control means relating to the second embodiment of the present invention.

Fig. 11 Fig. 11 shows a horizontal cross sectional drawing of the same gas flow volume control means.

Fig. 12 Fig. 12 is a cross sectional drawing along line [12]-[12] of Fig. 11.

Fig. 13 Fig. 13 is a top view of a conventional gas injector.

Fig. 14 Fig. 14 is a cross sectional drawing along line [14]-[14] of Fig. 13.

Fig. 15 Fig. 15 is a cross sectional drawing along line [15]-[15] of Fig. 14.

Fig. 16 Fig. 16 is a schematic perspective view of a conventional film formation apparatus.

Fig. 17 Fig. is a schematic drawing which shows the exhaust tube arranged in the vicinity of the gas injector.

Explanation of Codes

51… gas injector, 52… base plate, 53… bottom plate, 54… center plate, 55… top plate, 58… 1st reaction gas introduction hole, 59… 1st reaction gas introduction hole, 60… 2nd reaction gas introduction hole, 61… 2nd reaction gas introduction hole, 62… inert gas introduction hole, 63… 1st gas conduit for 1st reaction gas, 64… 1st gas conduit for 1st reaction gas, 66… 2nd reaction gas conduit, 67… 2nd reaction gas conduit, 68… 2nd reaction gas plenum chamber, 70… 2nd reaction gas plenum chamber, 72… partition, 75… 1st gas conduit for inert gas, 77… 2nd gas conduit for 1st reaction gas, 78… 2nd gas conduit for 1st reaction gas, 80… 2nd reaction gas spray nozzle, 81… 2nd reaction gas spray nozzle, 83… partition, 84… 2nd gas conduit for inert gas, 85… inert gas plenum chamber, 92… 3rd gas conduit for 1st reaction gas, 93… 3rd gas conduit for 1st reaction gas, 94… 1st reaction gas plenum chamber, 96… 1st reaction gas plenum chamber, 98… partition, 100… inert gas spray nozzle, 105… 1st reaction gas spray nozzle, 106… partition, and 107… 1st reaction gas spray nozzle.

Fig. 1

58 1st reaction gas introduction hole
62 inert gas introduction hole
61 2nd reaction gas introduction hole

Fig. 9

MasterWord Services

Fig. 2

Fig. 3

Fig. 5

Fig. 17

Fig. 4

Fig. 6

Fig. 7

Fig. 12

Fig. 8

Fig. 10

Fig. 15

Fig. 11

Fig. 13

Fig. 14

Fig. 16

る。

【図６】図４における[６]－[６]線方向の断面図である。

【図７】図４における[７]－[７]線方向の断面図である。

【図８】図５における[８]－[８]線方向の断面図である。

【図９】同ガスインジェクタと、これに接続されるガス導入管との接続関係を示す概略図である。

【図１０】本発明の第２の実施の形態に係るガス流量制御手段の外観斜視図である。

【図１１】同ガス流量制御手段の横断面図である。

【図１２】図１１における[１２]－[１２]線方向の断面図である。

【図１３】従来のガスインジェクタの上面図である。

【図１４】図１３における[１４]－[１４]線方向の断面図である。

【図１５】図１４における[１５]－[１５]線方向の断面図である。

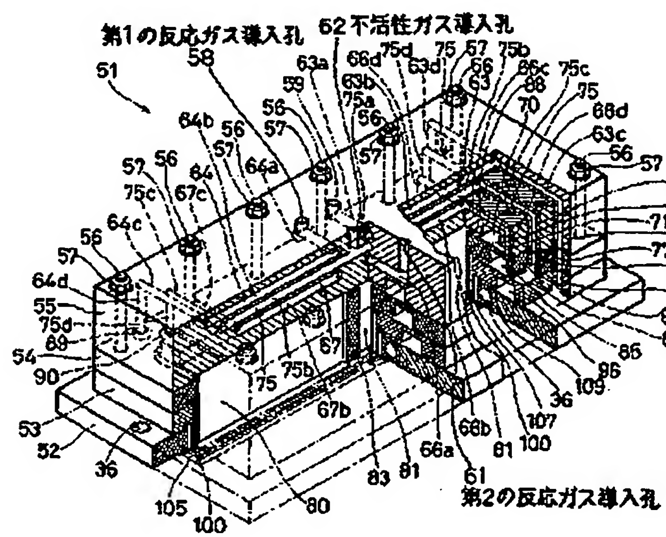
【図１６】従来の成膜装置の概略斜視図である。

【図１７】ガスインジェクタ周囲に配設された排気管を示す概略図である。

【符号の説明】

＊５１……ガスインジェクタ、５２……ベースプレート、５３……ボトムプレート、５４……センタープレート、５５……トッププレート、５８……第１の反応ガス導入孔、５９……第１の反応ガス導入孔、６０……第２の反応ガス導入孔、６１……第２の反応ガス導入孔、６２……不活性ガス導入孔、６３……第１の反応ガス用第１ガス通路、６４……第１の反応ガス用第１ガス通路、６６……第２の反応ガス用通路、６７……第２の反応ガス用通路、６８……第２の反応ガス用プレナムチャンバ、７０……第２の反応ガス用プレナムチャンバ、７２……隔壁、７５……不活性ガス用第１ガス通路、７７……第１の反応ガス用第２ガス通路、７８……第１の反応ガス用第２ガス通路、８０……第２の反応ガス噴出ノズル、８１……第２の反応ガス噴出ノズル、８３……隔壁、８４……不活性ガス用第２ガス通路、８５……不活性ガス用プレナムチャンバ、９２……第１の反応ガス用第３ガス通路、９３……第１の反応ガス用第３ガス通路、９４……第１の反応ガス用プレナムチャンバ、９６……第１の反応ガス用プレナムチャンバ、９８……隔壁、１００……不活性ガス噴出ノズル、１０５……第１の反応ガス噴出ノズル、１０６……隔壁、１０７……第１の反応ガス噴出ノズル。

【図１】



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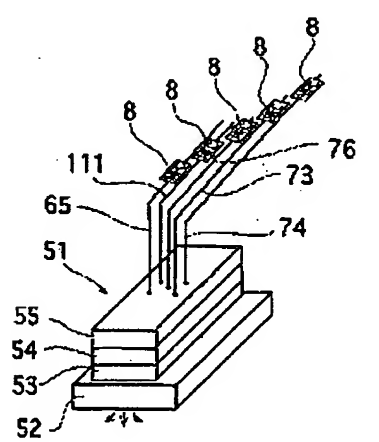

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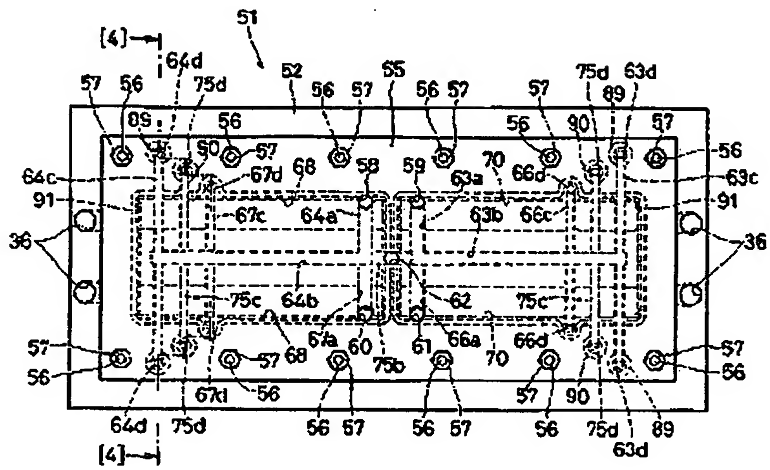
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75b
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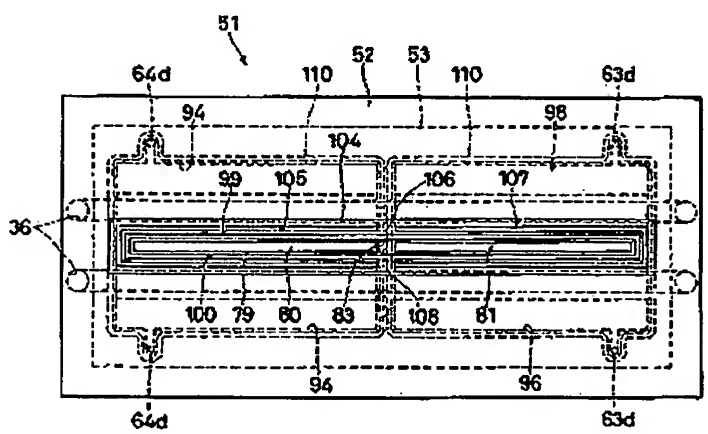
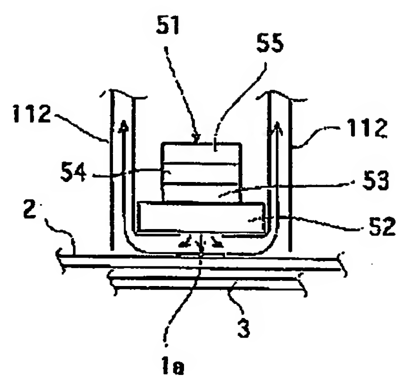
[4]

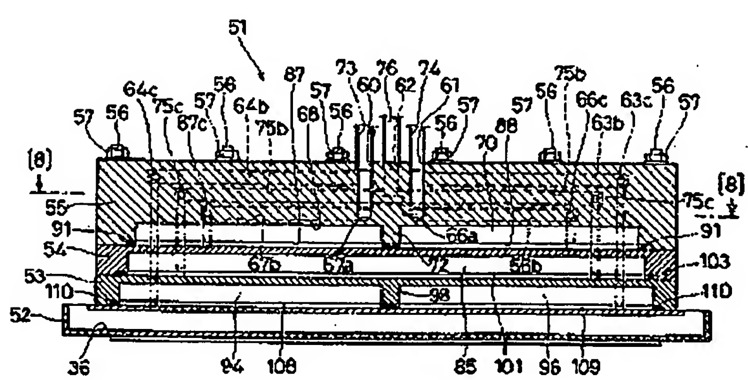
【図３】


51
52
53
64d
63d
110
94
98
104
99
105
106
107
36
100
79
80
83
108
81
96

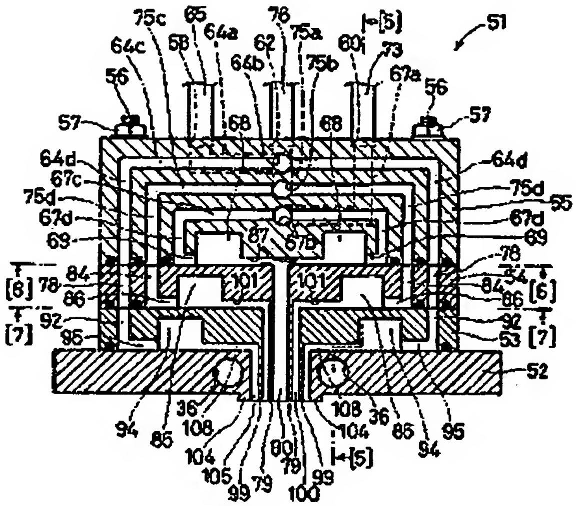
【図１７】


51
55
112
54
53
2
52
3
1a

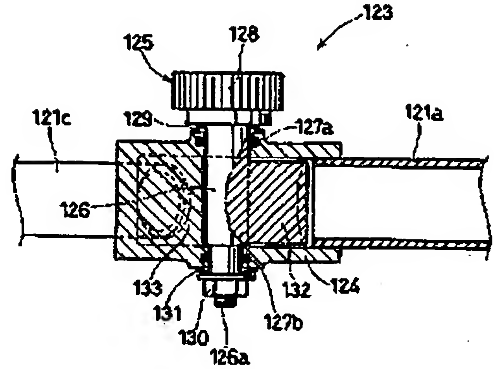
【図５】


51
[8]
55
91
54
53
110
52
36
56
57
64c
75c
67c
64b
75b
87
68
73
60
76
62
74
61
88
70
66c
63c
63b
66a
67b
67a
72
98
103
94
108
85
101
96
109

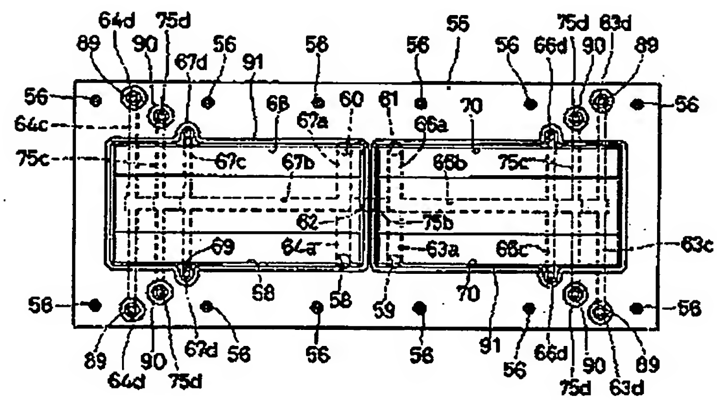
【図４】



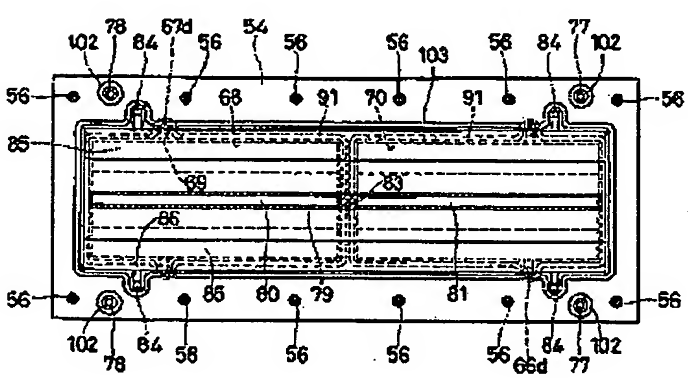
【図１２】



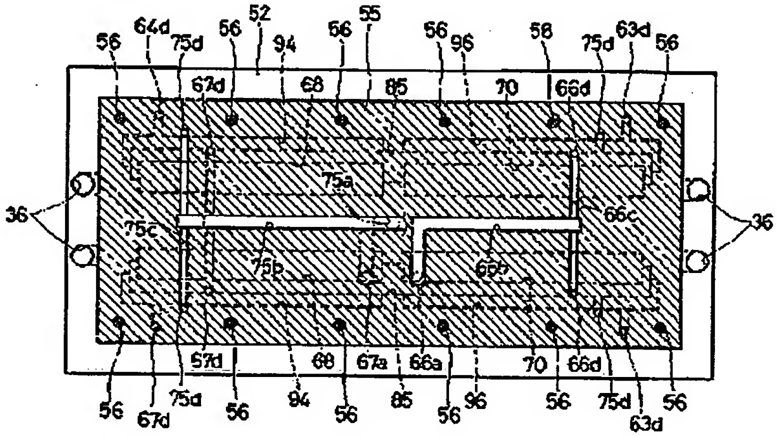
【図６】



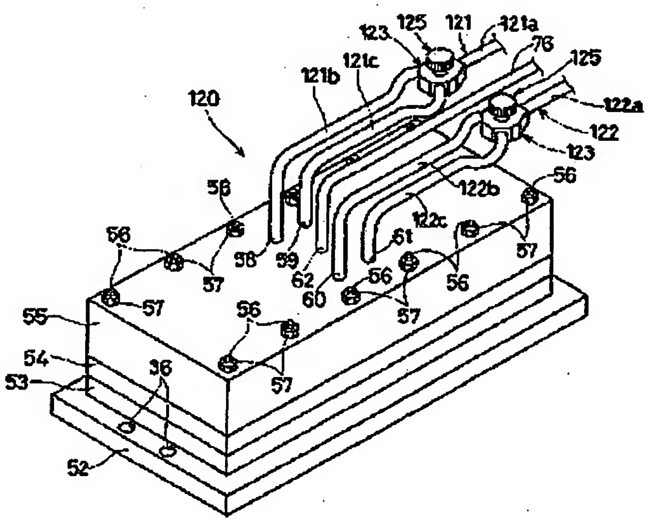
【図７】



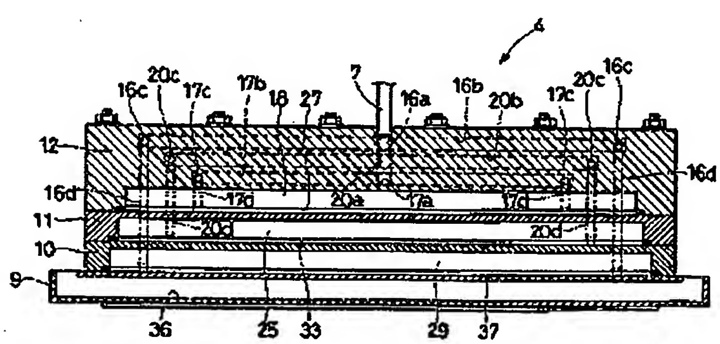
【図８】



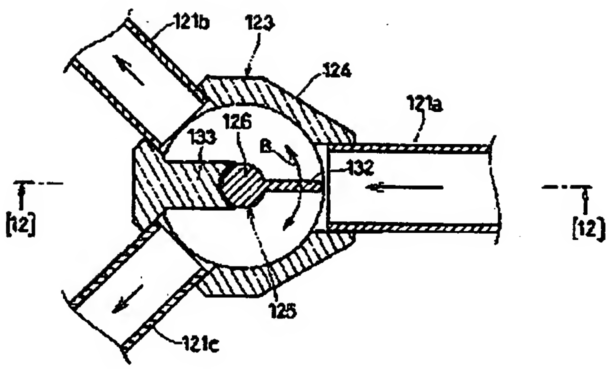
【図１０】



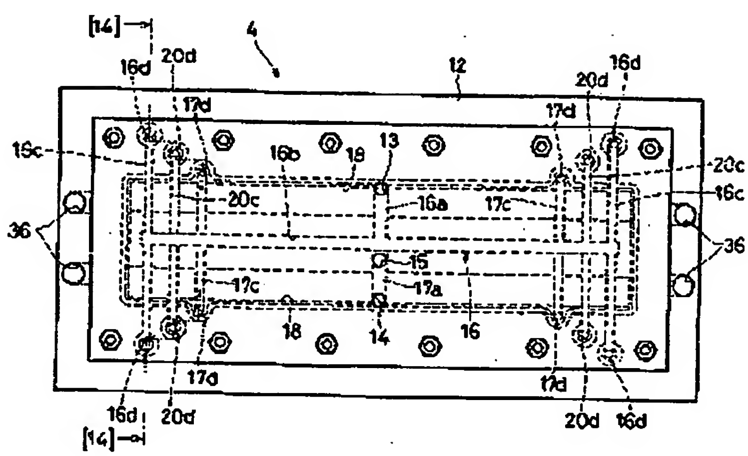
【図１５】



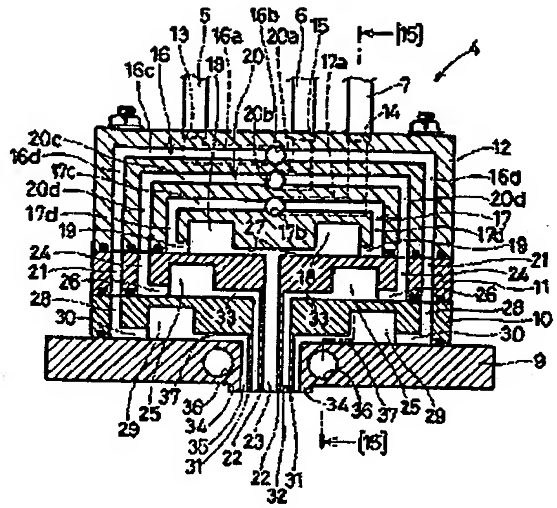
【図１１】


121b
123
124
121a
126
133
B
132
[12]
[12]
125
121c

【図１３】


[14]
4
12
16d
20d
17d
16c
16b
18
13
20c
16a
17c
36
15
17a
14
16
17d
16d
20d
[14]

【図14】



【図16】